Human Health Risk Assessment for Smelter/Tailings Soils Investigation Unit (S/TSIU)

Presentation to Community Workgroup
Hurley, NM

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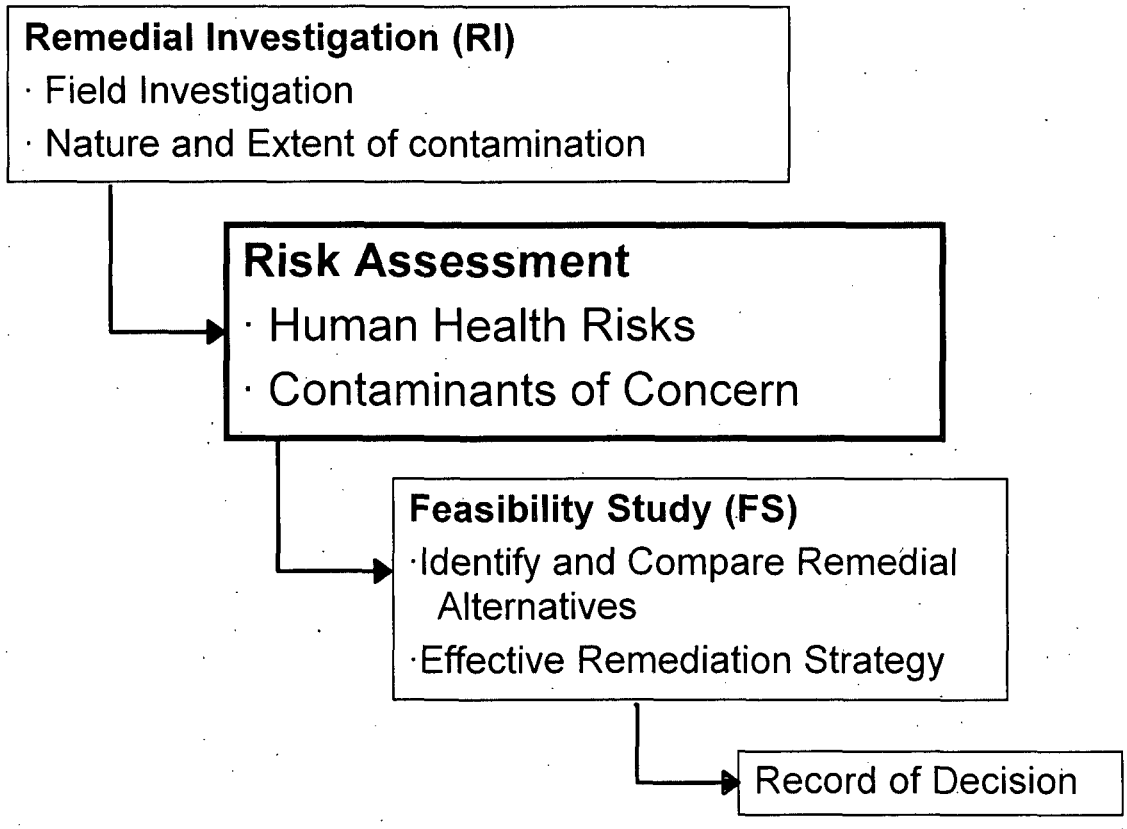
Gradient
CORPORATION

Overview

- Risk Assessment overview
- Receptors and pathways evaluated
- Summary of risk results

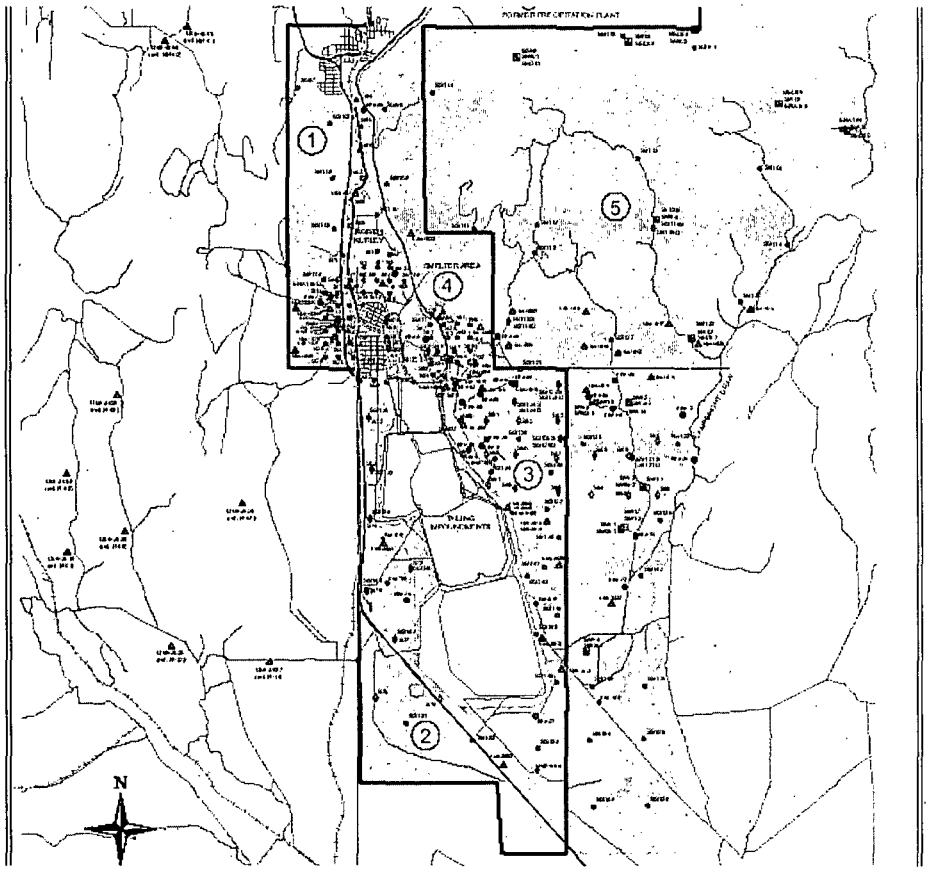
CERCLA RI/FS Process



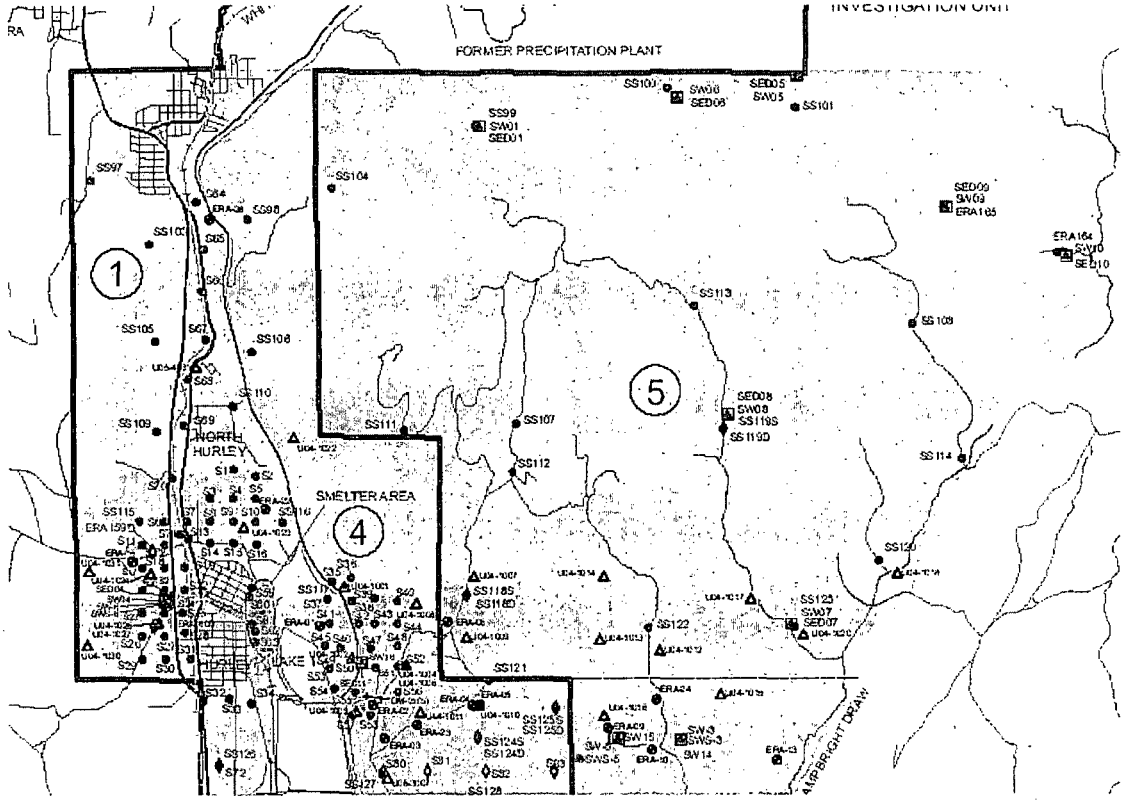
Purpose of Risk Assessment

- Estimate probability of adverse health effects from exposure to chemicals
- Consider possible present and future exposures
- Inputs
  - Environmental data
  - Exposure parameters
  - Chemical potency or toxicity
- Approach yields conservative estimates of possible risks (more likely to overestimate risk)
- Used to determine need for and extent of remediation

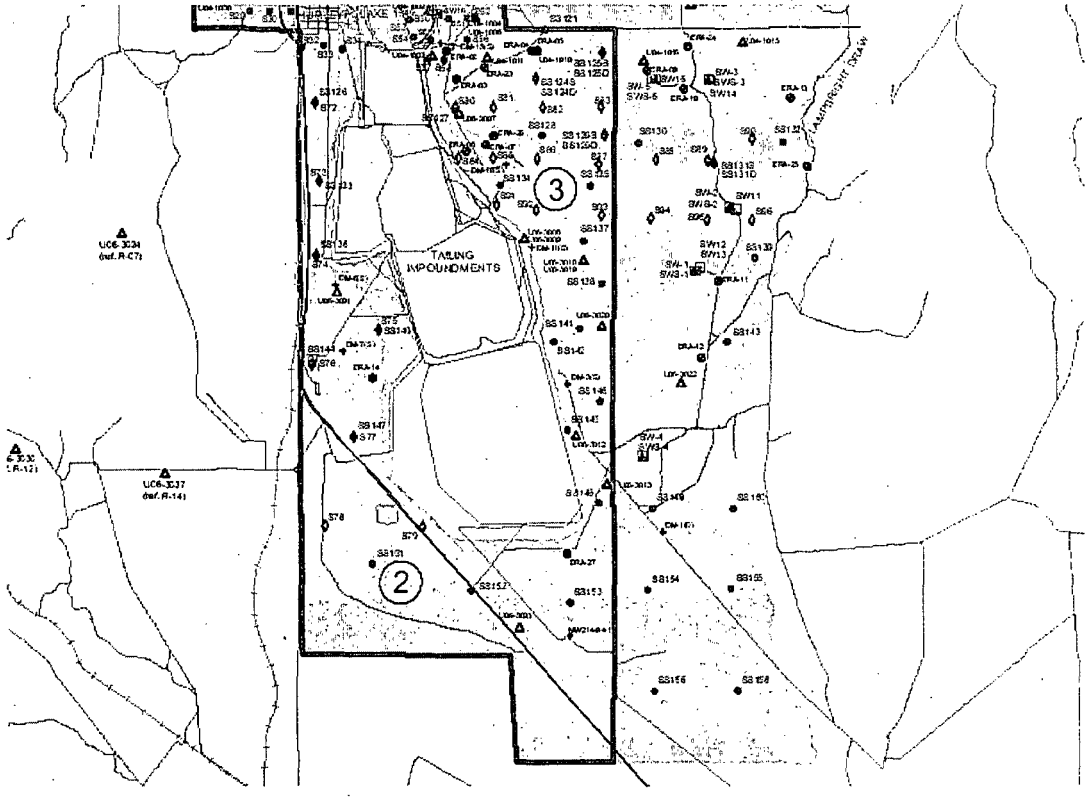
Smelter/Tailing Soils Investigation Unit



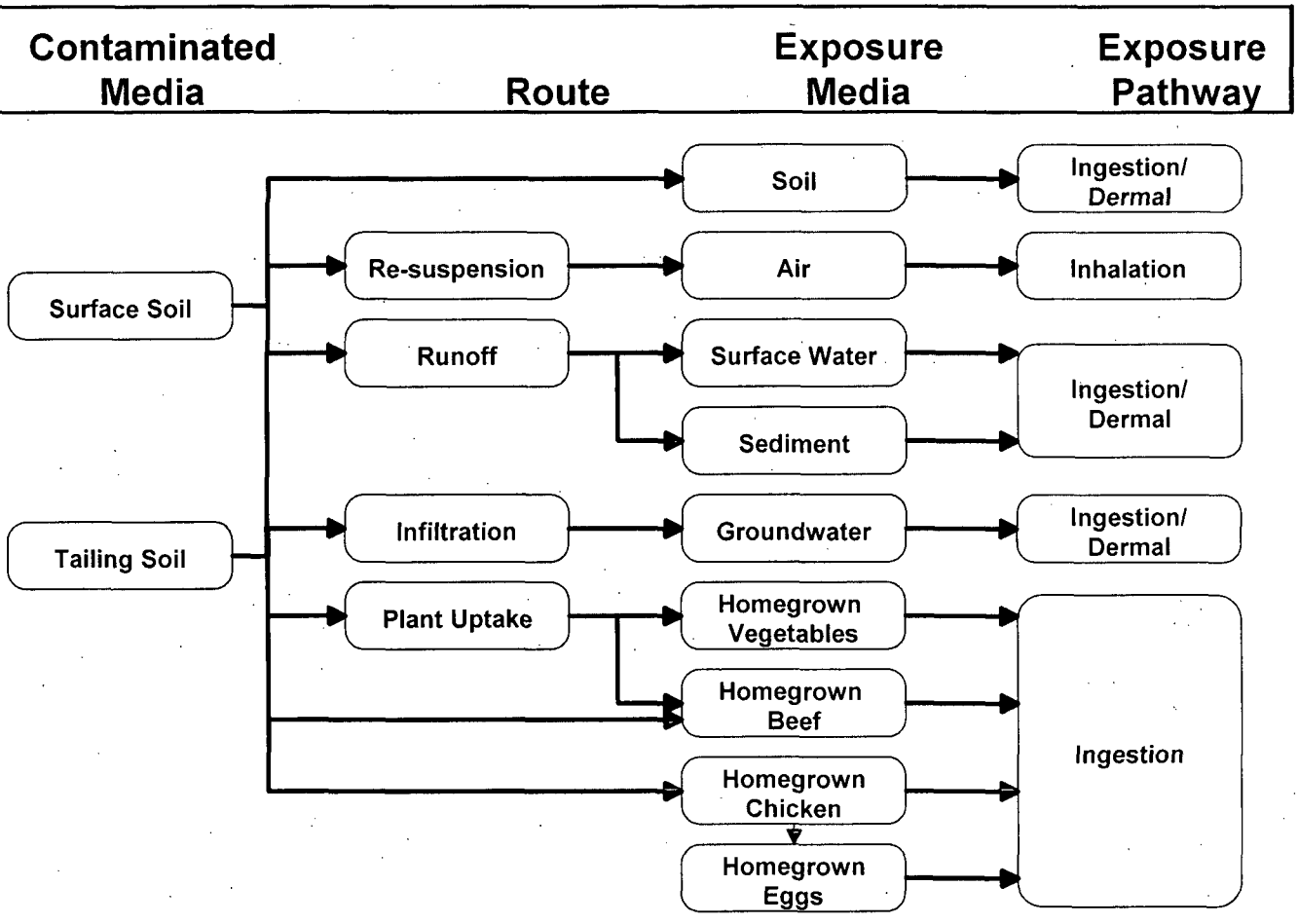
Smelter/Tailing Soils Investigation Unit



Smelter/Tailing Soils Investigation Unit



Exposure Pathways



Receptors Evaluated

- Current Residents (Child and Adult)
- Future Residents (Child and Adult)
- Construction Workers (Adult)
- Ranchers (Adult)
- Recreators (swimming, hiking, *etc.*) (Adolescents)
- Trespassers (swimming, hiking, *etc.*) (Adolescents)
- Industrial Workers at Smelter (Adult)

Receptors by Exposure Area

	Exposure Area						
Receptor	EA 1	EA 2	EA 3	EA 4	EA 5	Reference	Smelter
Current Resident (Child & Adult)		X					
Future Resident (Child & Adult)	X	X	X	X	X	X	
Construction Worker	X	X					
Rancher	X	X			X		
Industrial Worker							X
Recreator-Hiker	X				X		
Recreator-Swimmer					X		
Trespasser-Hiker			X	X			
Trespasser-Swimmer				X			

Pathways Evaluated

	Pathway					
Receptor	Soil Ingestion	Dermal Contact with Soil	Dust Inhalation	Ingestion of Local Beef, Chicken, Eggs & Vegetables	Ingestion of Groundwater	Dermal Contact with Groundwater
Resident (Child & Adult)	X	X	X	X	X	X
Construction Worker	X	X	X			
Rancher	X	X	X			
Industrial Worker	X	X	X			

Pathways Evaluated

	Pathway						
Receptor	Soil *Ingestion*	Dermal Contact *with Soil*	Dust *Inhalation*	Ingestion of Surface *Water*	Dermal Contact with Surface *Water*	Ingestion of *Sediment*	Dermal Contact with *Sediment*
Recreator-Hiker	**X**	**X**	**X**				
Trespasser-Hiker	**X**	**X**	**X**				
Recreator-Swimmer				**X**	**X**	**X**	**X**
Trespasser-Swimmer				**X**	**X**	**X**	**X**

Chemicals Evaluated

- Chemicals of concern at S/TSIU are metals
- Metals are elements that can not be broken down into simpler substances
- Metals are present naturally in the environment (soil, food)
- Some metals are essential nutrients
- Metals evaluated
  - Soil: Arsenic, Cadmium, Copper, Iron, Thallium
  - Groundwater: Manganese

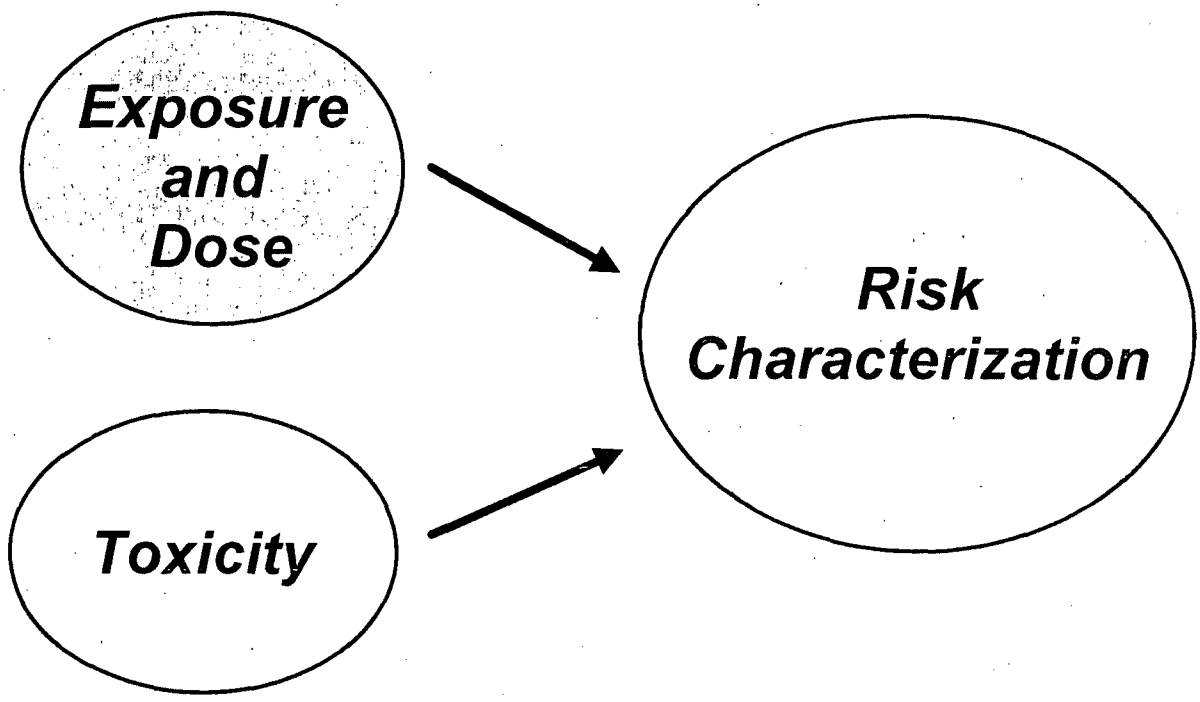
Soil Concentrations Compared to Reference Area (Background)

Mean Soil Concentrations (mg/kg)
in S/TSIU Exposure Areas *vs.* Reference Area

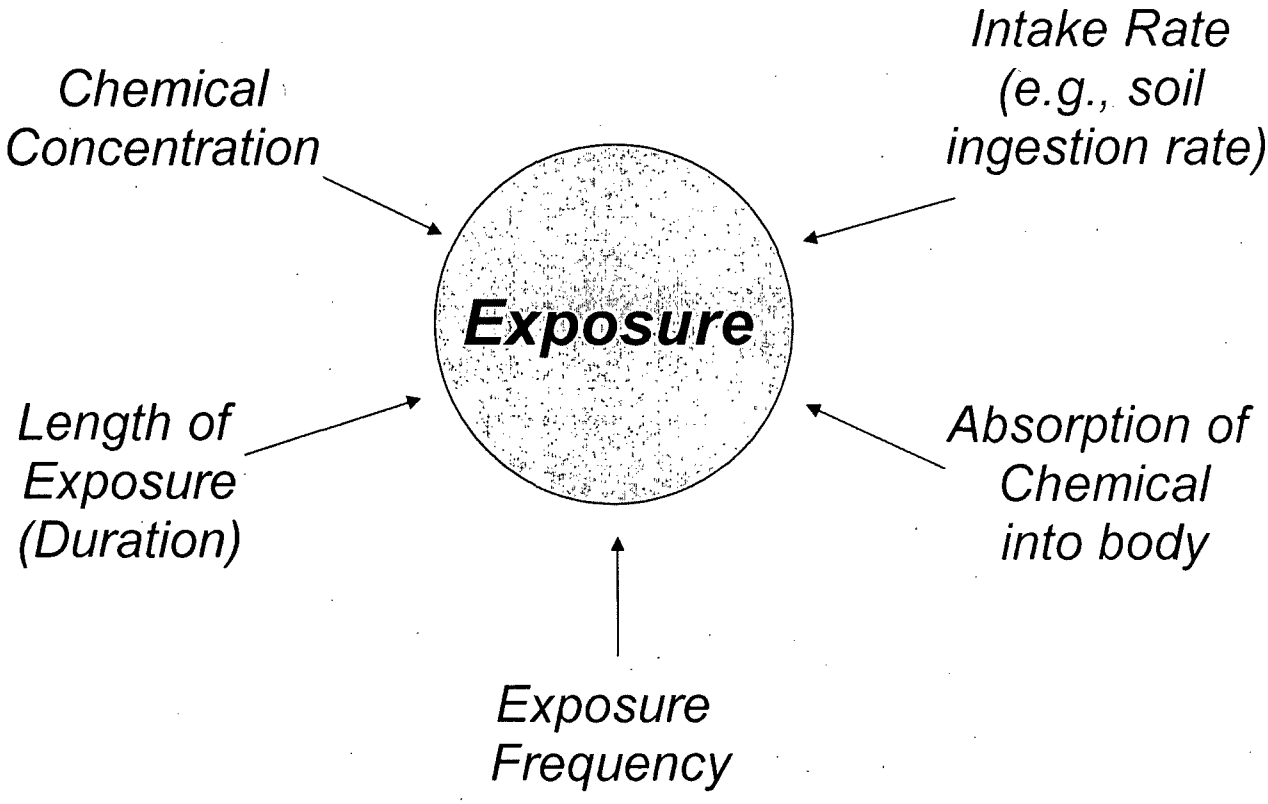
	EA1	EA2	EA3	EA4	EA5	Smelter	Reference
Arsenic	2.41	2.50	3.51	**4.38**	1.93	**18.30**	2.12
Cadmium	0.96	**0.99**	4.56	**3.40**	0.47	**5.94**	0.58
Copper	**638**	**1,058**	**1,297**	**4,306**	**370**	**18,700**	136
Iron	21,527	22,491	45,209	21,014	22,471	43,140	36,600
Thallium	0.34	0.37	0.35	0.48	0.27	0.48	7.28

Blue: Mean is greater than Reference Area concentration, with statistical significance.

Risk Assessment



Quantifying Exposure



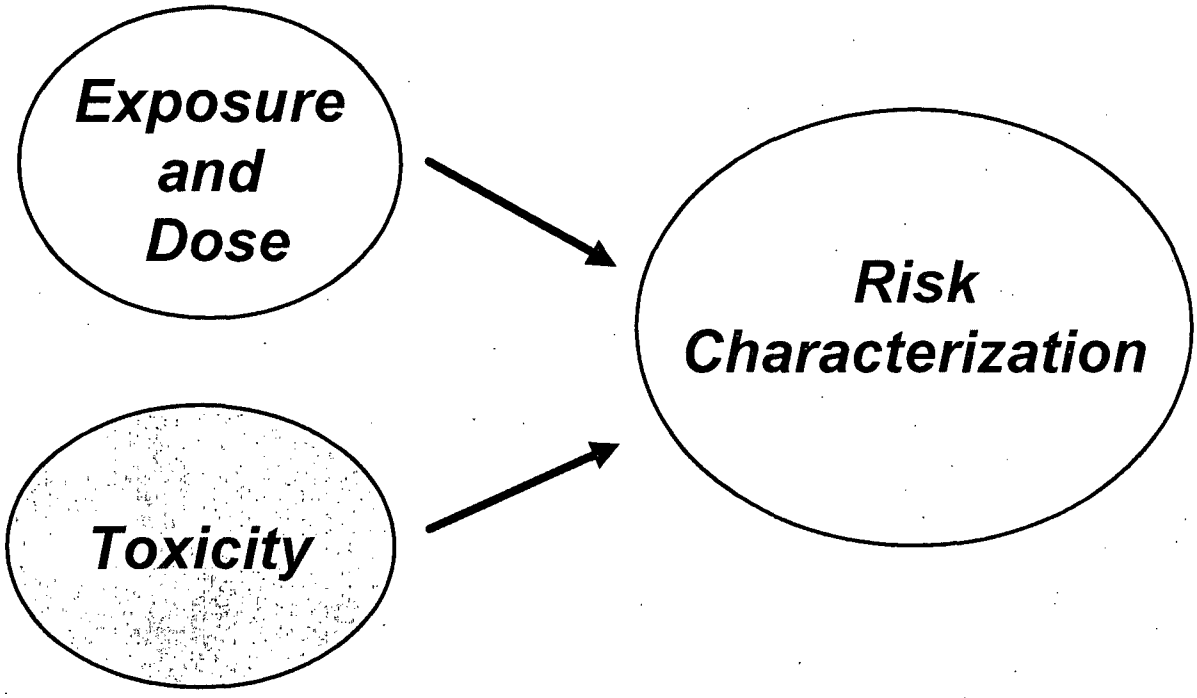
Example of Exposure Calculation

Amount of metal taken into the body from soil = *Amount of soil ingested* X *Amount of metal in soil* X *Percent of metal absorbed*

Risk Assessment

- Noncancer health effects
  - Arsenic, Cadmium, Copper, Iron, Thallium Manganese
- Cancer health effects
  - Arsenic, Cadmium (inhalation only)
- Reasonable Maximum Exposure (RME)
  - High end exposures
- Central Tendency Exposure (CTE)
  - Average exposures

Risk Assessment



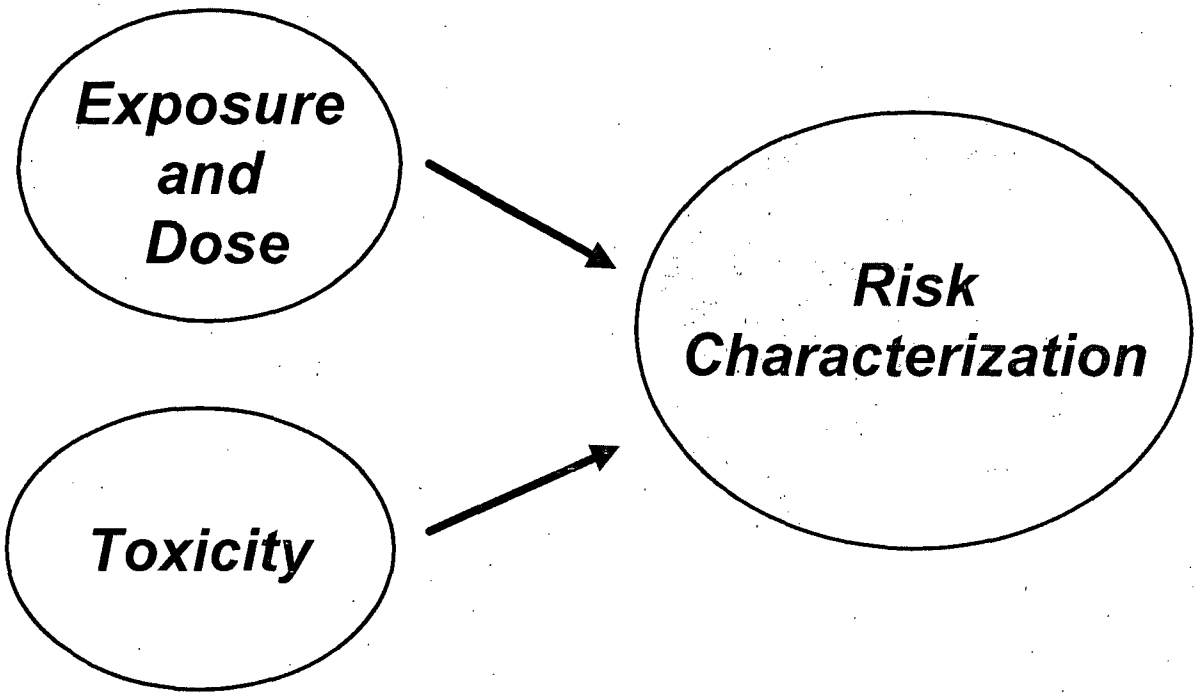
Toxicity - Assessment of Noncancer Health Effects

- Reference Dose (RfD) = Lifetime daily dose unlikely to cause noncancer effects
- Based on:
  - "No observed adverse effect level" or "Lowest observed adverse effect level" in animal or human studies
  - Uncertainty factors
    - Animal to human extrapolation
    - Sensitive subpopulations

Toxicity - Assessment of Cancer Effects

- Cancer Slope Factor (CSF)
  - Risk of cancer per unit dose or concentration
- Based on animal or human cancer data

Risk Assessment

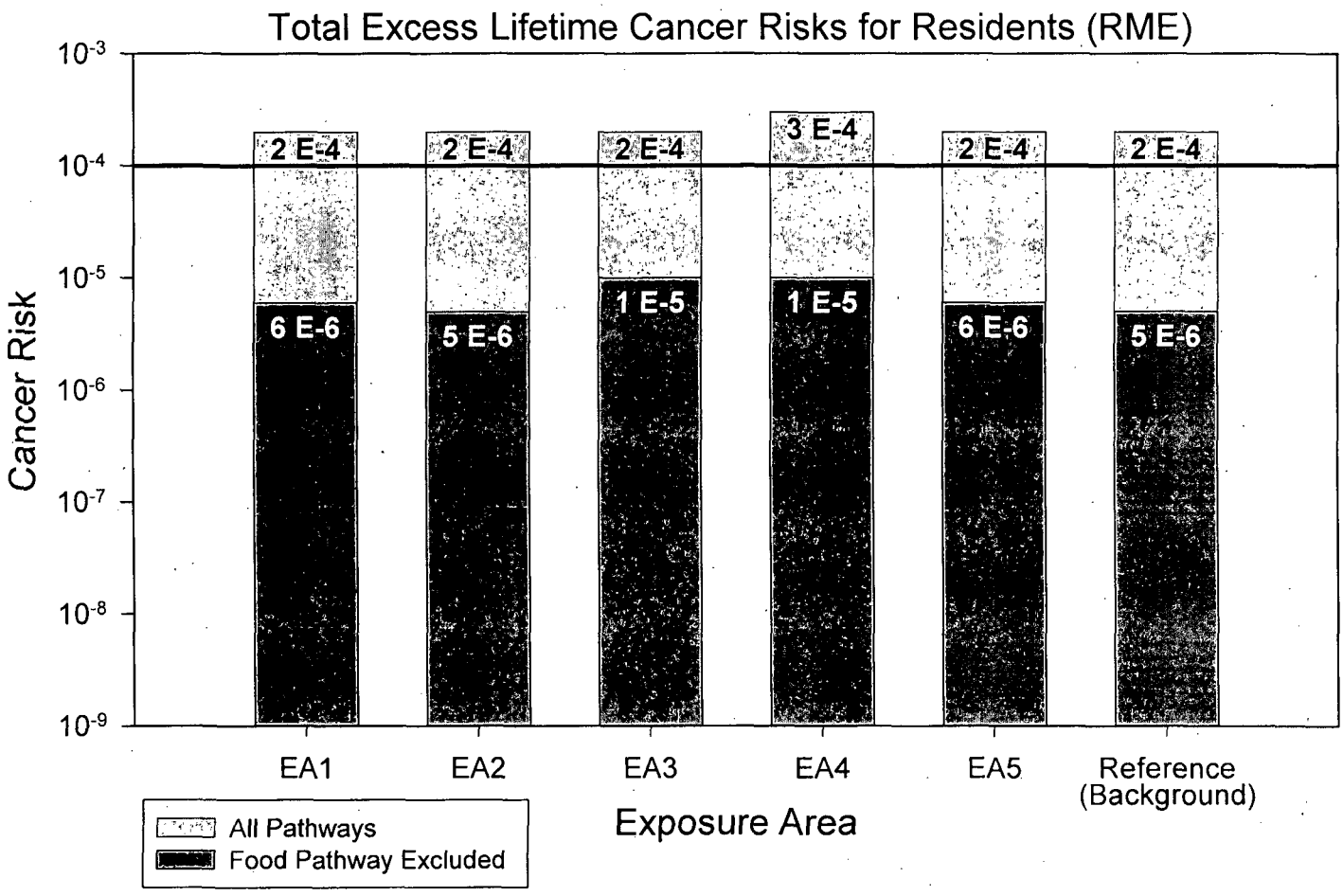


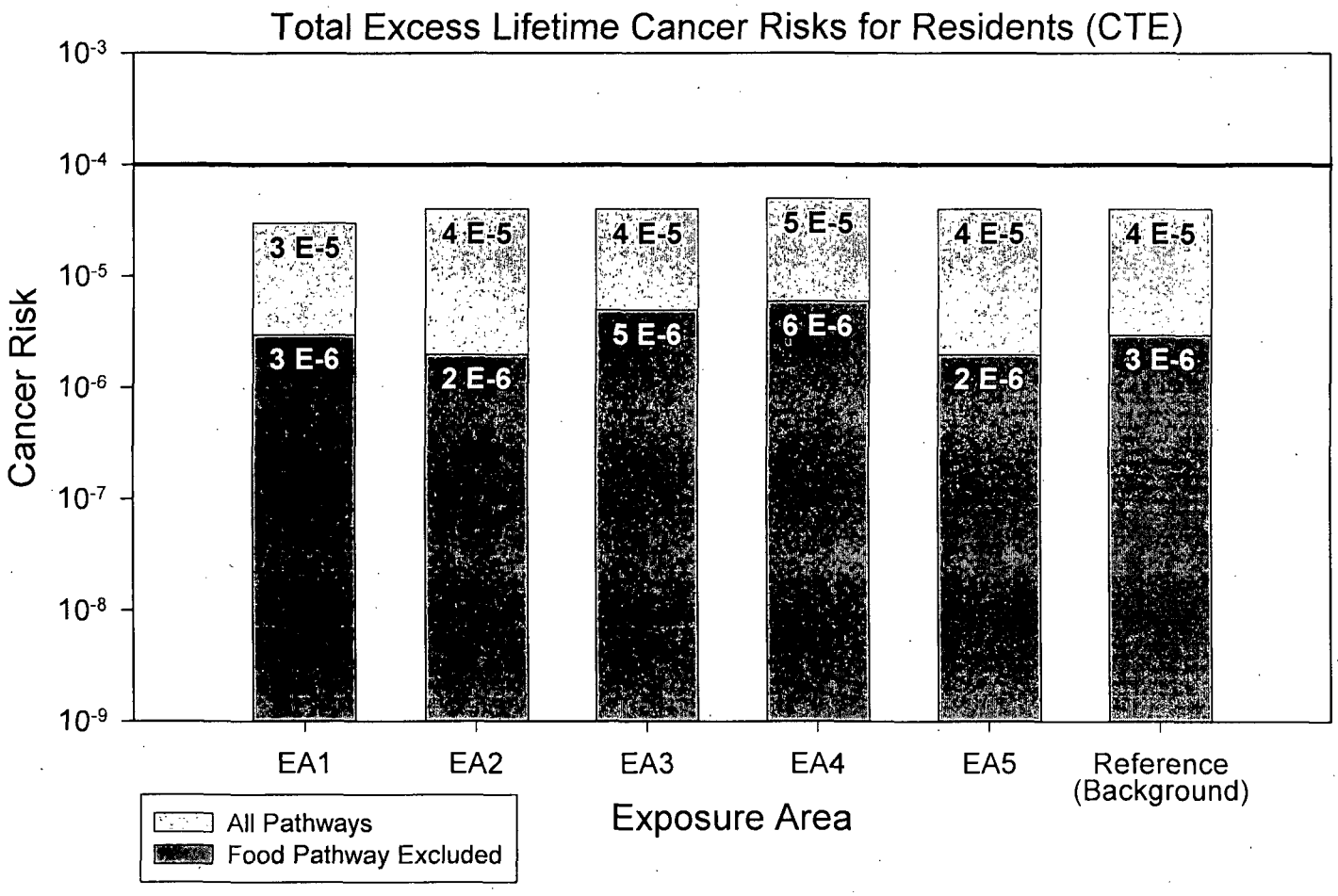
Risk Characterization

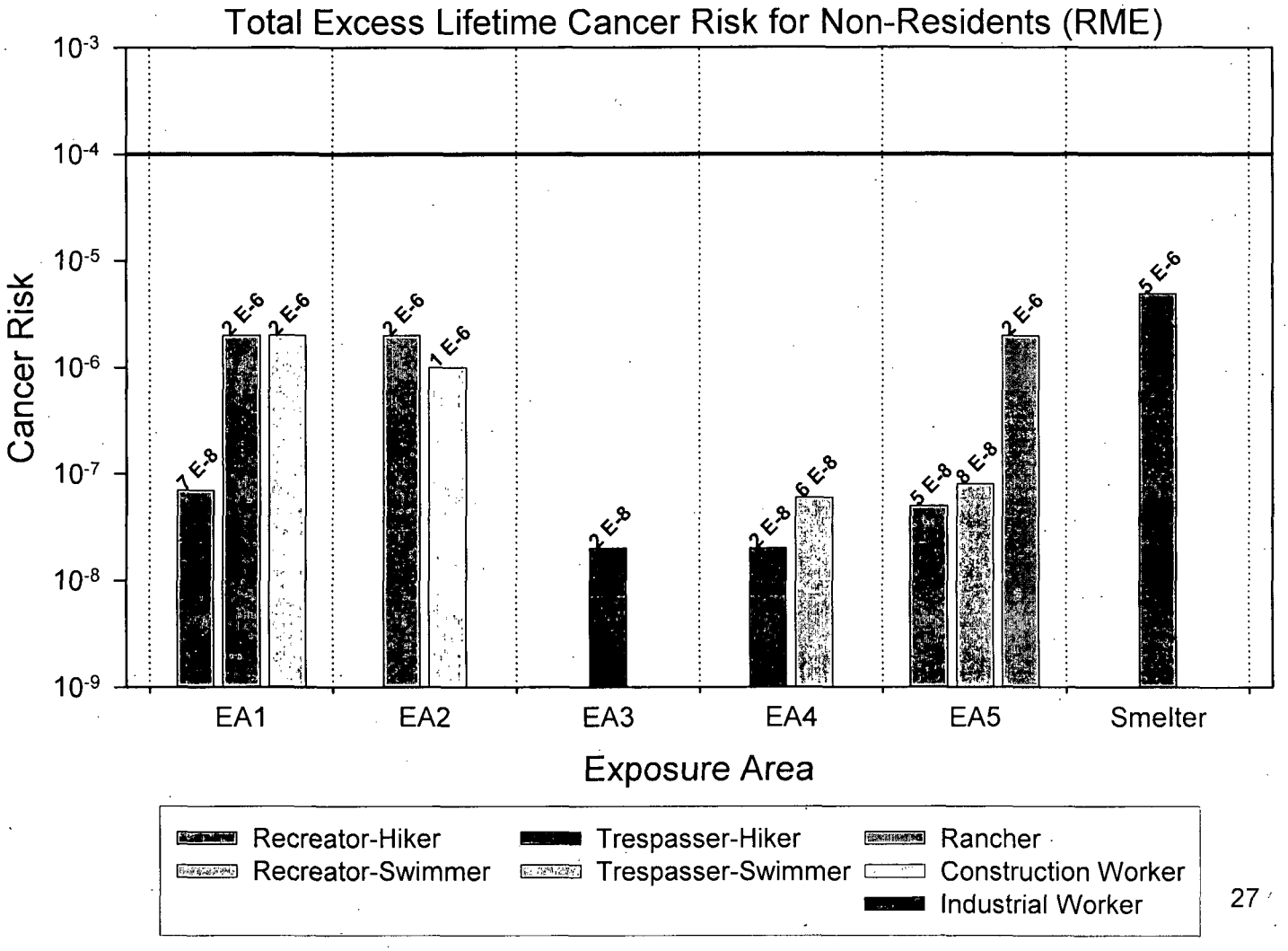
- Noncancer risk results reported as Hazard Quotient (HQ)
  - HQ = Dose/RfD
  - HQ < 1 indicates noncancer effects unlikely
- Cancer risks reported as incremental probability of developing cancer due to site exposure, *i.e.*, "excess lifetime cancer risk"
  - Cancer risk = CSF/Dose
  - EPA target range: "1 in a million" to "1 in 10,000"
  - Also written as $1x10^{-6}$ to $1x10^{-4}$, or 0.000001 – 0.0001
  - Background cancer risk ~ "250,000 in a million", or 0.25 (1 in 4)

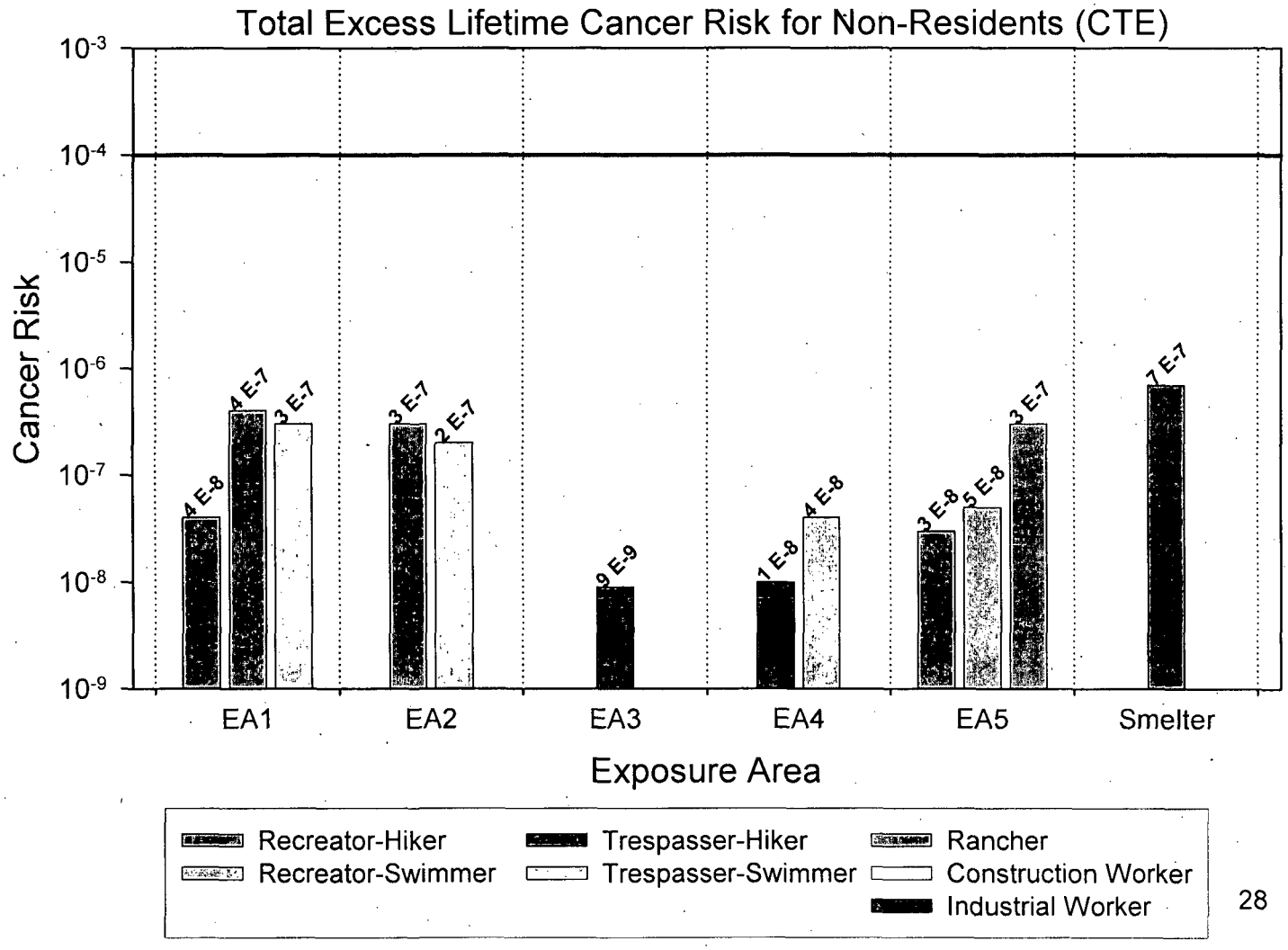
Risk Results

- Cancer – RME & CTE
  - Residents
  - Non-Residents
- Noncancer – RME & CTE
  - Residents
  - Non-Residents


Total Excess Lifetime Cancer Risks for Residents (RME)
Cancer Risk
10-3
10-4
10-5
10-6
10-7
10-8
10-9
2 E-4
2 E-4
2 E-4
3 E-4
2 E-4
2 E-4
6 E-6
5 E-6
1 E-5
1 E-5
6 E-6
5 E-6
EA1
EA2
EA3
EA4
EA5
Reference (Background)
Exposure Area
All Pathways
Food Pathway Excluded


Total Excess Lifetime Cancer Risks for Residents (CTE)
Cancer Risk
10-3
10-4
10-5
10-6
10-7
10-8
10-9
3 E-5
3 E-6
4 E-5
2 E-6
4 E-5
5 E-6
5 E-5
6 E-6
4 E-5
2 E-6
4 E-5
3 E-6
EA1
EA2
EA3
EA4
EA5
Reference (Background)
Exposure Area
All Pathways
Food Pathway Excluded


Total Excess Lifetime Cancer Risk for Non-Residents (RME)
Cancer Risk
10-3
10-4
10-5
10-6
10-7
10-8
10-9
7 E-8
2 E-6
2 E-6
2 E-6
1 E-6
2 E-8
2 E-8
6 E-8
5 E-8
8 E-8
2 E-6
5 E-6
EA1
EA2
EA3
EA4
EA5
Smelter
Exposure Area
Recreator-Hiker
Recreator-Swimmer
Trespasser-Hiker
Trespasser-Swimmer
Rancher
Construction Worker
Industrial Worker


Total Excess Lifetime Cancer Risk for Non-Residents (CTE)
Cancer Risk
10-3
10-4
10-5
10-6
10-7
10-8
10-9
4 E-8
4 E-7
3 E-7
3 E-7
2 E-7
9 E-9
1 E-8
4 E-8
3 E-8
5 E-8
3 E-7
7 E-7
EA1
EA2
EA3
EA4
EA5
Smelter
Exposure Area
Recreator-Hiker
Recreator-Swimmer
Trespasser-Hiker
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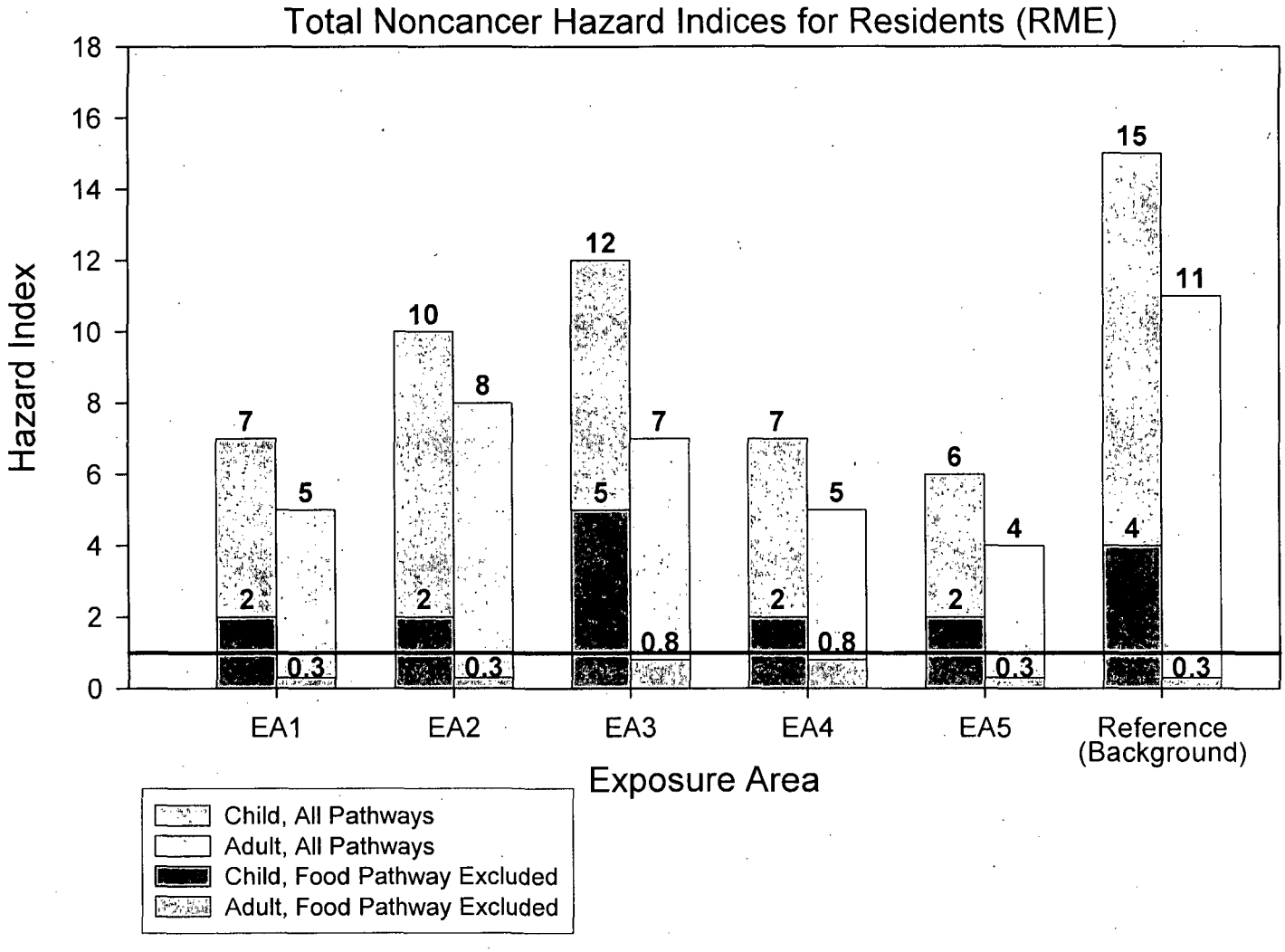
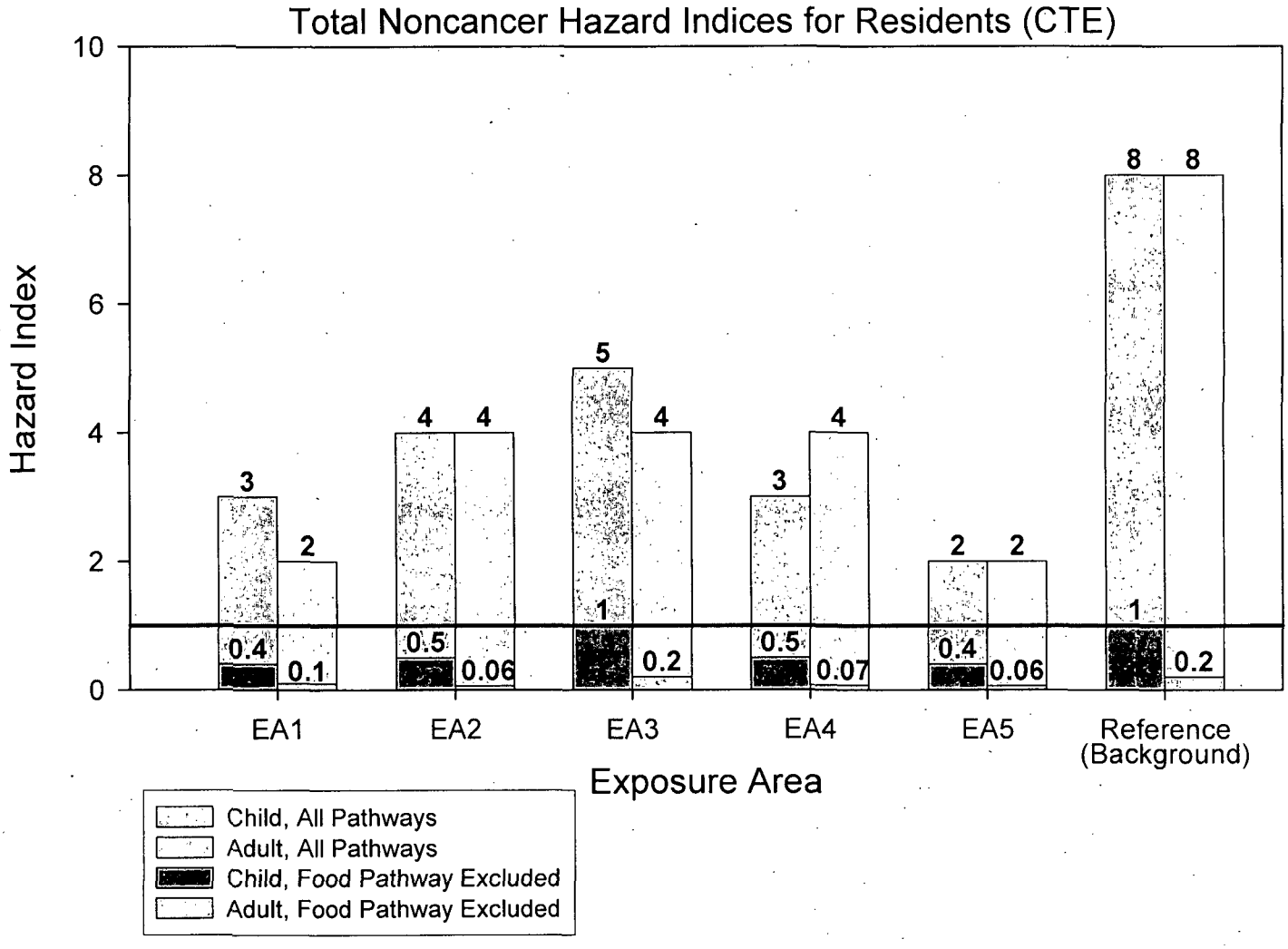
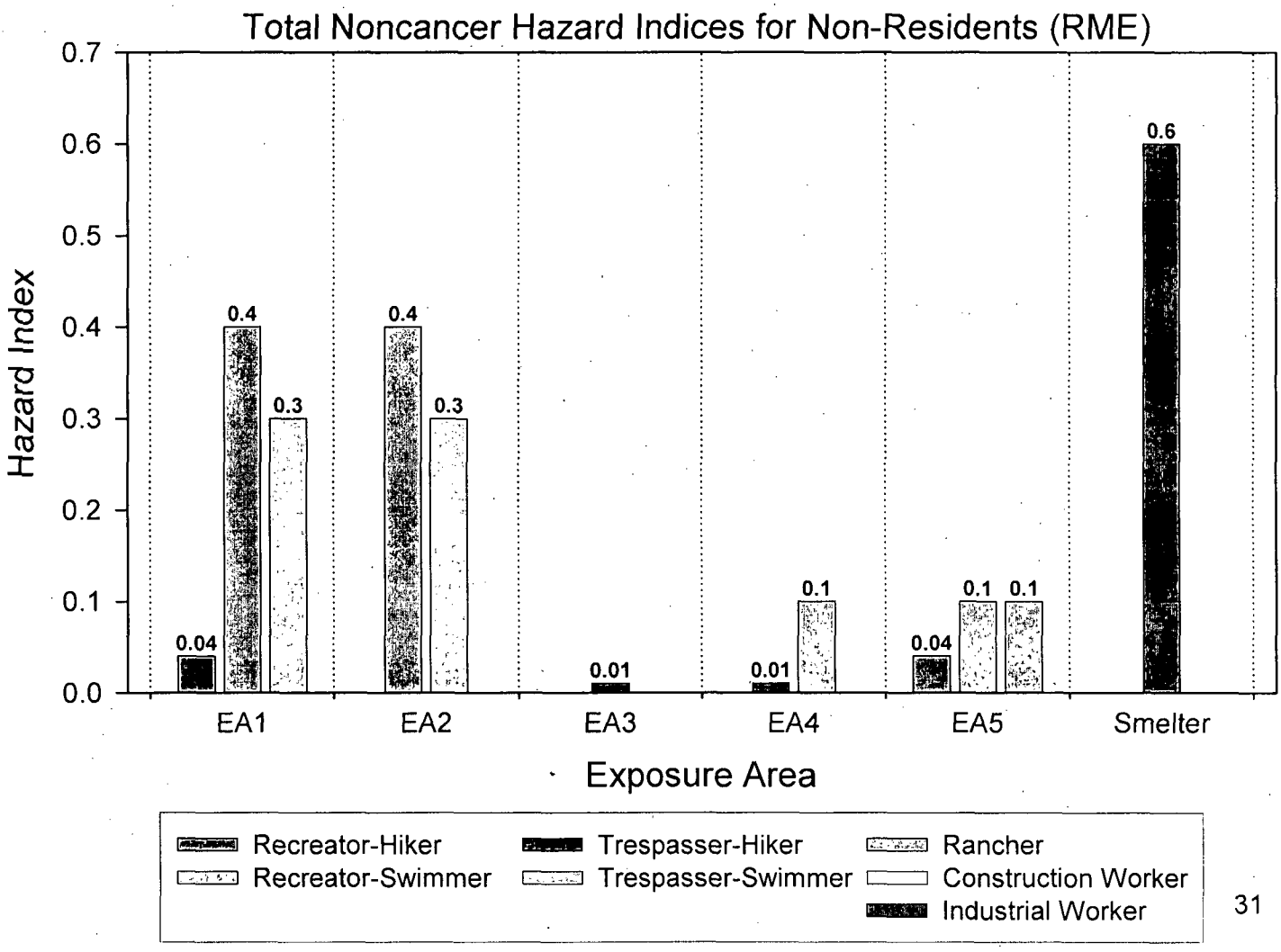
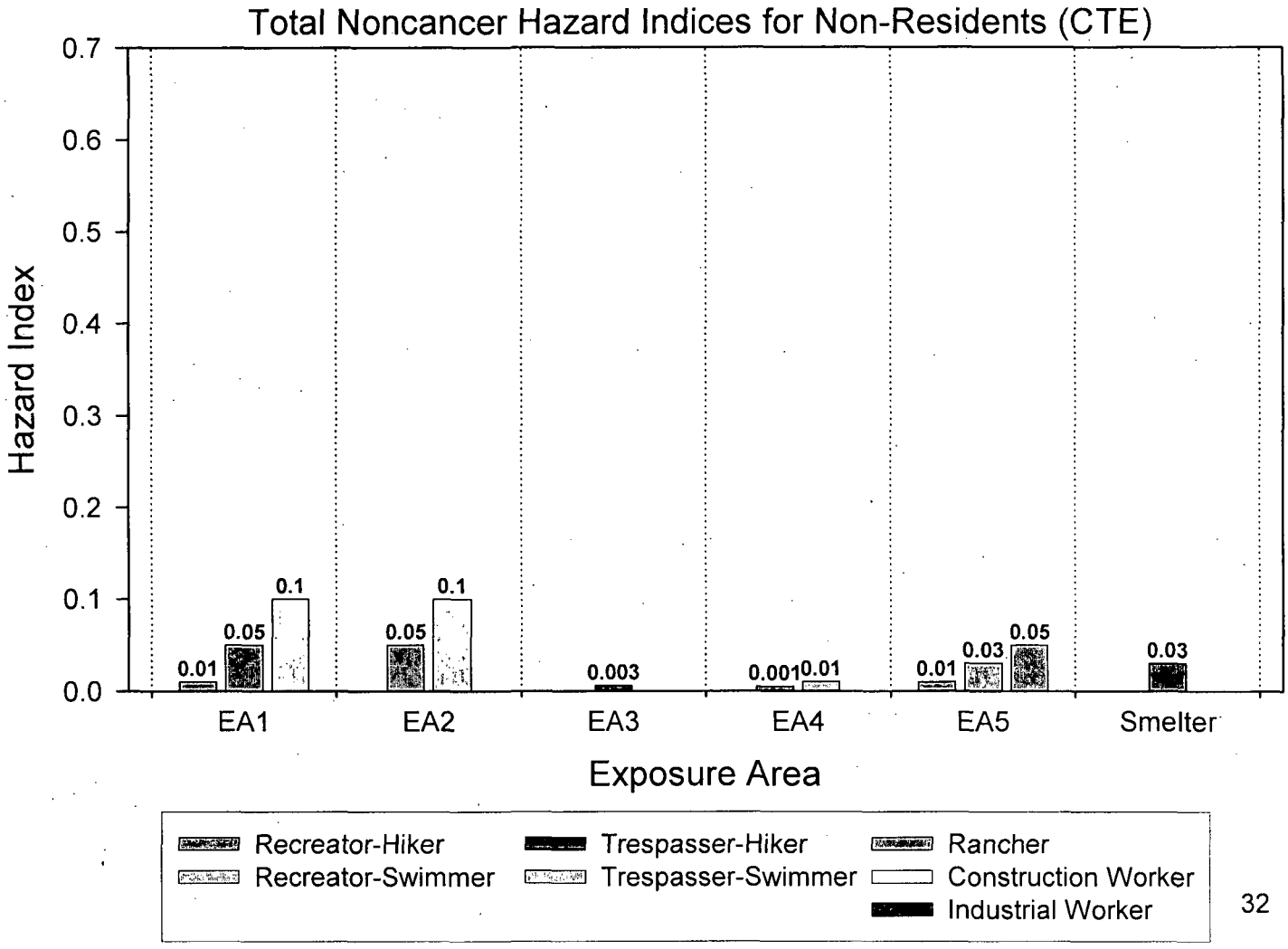

Total Noncancer Hazard Indices for Residents (RME)
Hazard Index
18
16
14
12
10
8
6
4
2
0
7
5
2
0.3
10
8
2
0.3
12
7
5
0.8
7
5
2
0.8
6
4
2
0.3
15
11
4
0.3
EA1
EA2
EA3
EA4
EA5
Reference (Background)
Exposure Area
Child, All Pathways
Adult, All Pathways
Child, Food Pathway Excluded
Adult, Food Pathway Excluded


Total Noncancer Hazard Indices for Residents (CTE)
Hazard Index
10
8
6
4
2
0
3
2
4
4
5
4
3
4
2
2
8
8
0.4
0.1
0.5
0.06
1
0.2
0.5
0.07
0.4
0.06
1
0.2
EA1
EA2
EA3
EA4
EA5
Reference (Background)
Exposure Area
Child, All Pathways
Adult, All Pathways
Child, Food Pathway Excluded
Adult, Food Pathway Excluded


Total Noncancer Hazard Indices for Non-Residents (RME)
Hazard Index
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.04
0.4
0.3
0.4
0.3
0.01
0.01
0.1
0.04
0.1
0.1
0.6
EA1
EA2
EA3
EA4
EA5
Smelter
Exposure Area
Recreator-Hiker
Recreator-Swimmer
Trespasser-Hiker
Trespasser-Swimmer
Rancher
Construction Worker
Industrial Worker


Total Noncancer Hazard Indices for Non-Residents (CTE)
Hazard Index
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.01
0.05
0.1
0.05
0.1
0.003
0.001
0.01
0.01
0.03
0.05
0.03
EA1
EA2
EA3
EA4
EA5
Smelter
Exposure Area
Recreator-Hiker
Recreator-Swimmer
Trespasser-Hiker
Trespasser-Swimmer
Rancher
Construction Worker
Industrial Worker

Major Contributors to Risk

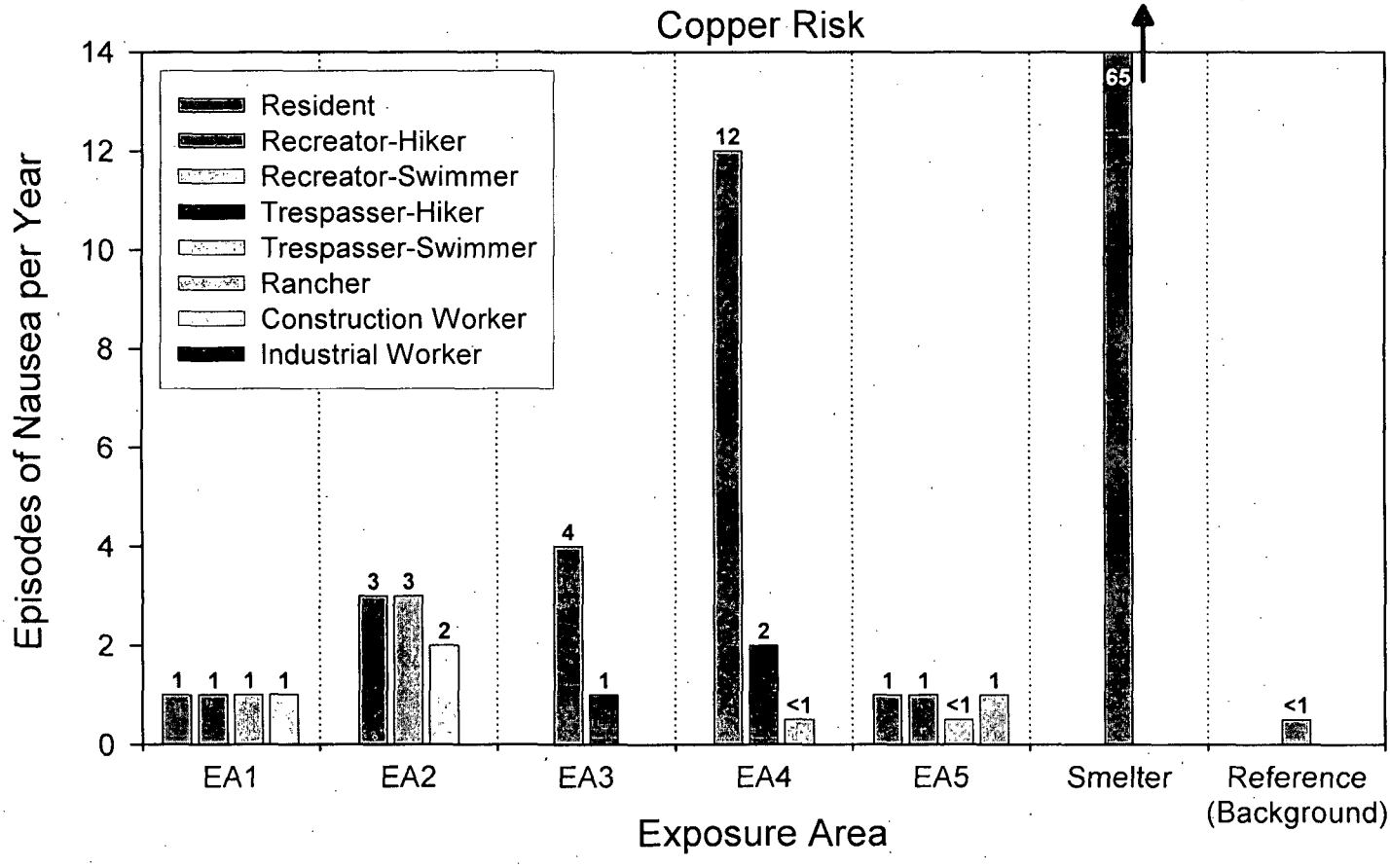
- Pathways with highest contribution to risk
  - Cancer
    - Residents: Locally-grown food, mainly vegetables
    - Swimmer: Surface water ingestion
    - Hiker, Rancher, Construction Worker, Industrial Worker: Soil ingestion
  - Noncancer
    - Residents: Locally-grown food, mainly beef, vegetables
    - Swimmer: Dermal contact with surface water & sediment
    - Rancher: Ingestion and Dermal contact with soil
    - Hiker, Construction Worker, Industrial Worker: Dermal contact with soil

Major Contributors to Risk

- Metals with highest contribution to risk
  - Cancer: Arsenic
  - Noncancer:
    - Residents: Iron, Thallium
    - Residents in Reference Area: Thallium
    - Hiker, Swimmer: Iron
    - Rancher, Construction Worker, Industrial Worker: Iron

Copper Risks from Soil Ingestion

- Copper risk evaluated using same methodology used to develop Copper RAC for Hurley Soils IU
- Most sensitive endpoint for copper toxicity is nausea
- Copper risk given as estimated number of nausea episodes per year
- Uses child-specific exposure factors; very conservative for adults


Copper Risk
Episodes of Nausea per Year
14
12
10
8
6
4
2
0
Resident
Recreator-Hiker
Recreator-Swimmer
Trespasser-Hiker
Trespasser-Swimmer
Rancher
Construction Worker
Industrial Worker
1 1 1 1
3 3 2
4 1
12 2 <1
1 1 <1 1
65
<1
EA1
EA2
EA3
EA4
EA5
Smelter
Reference (Background)
Exposure Area

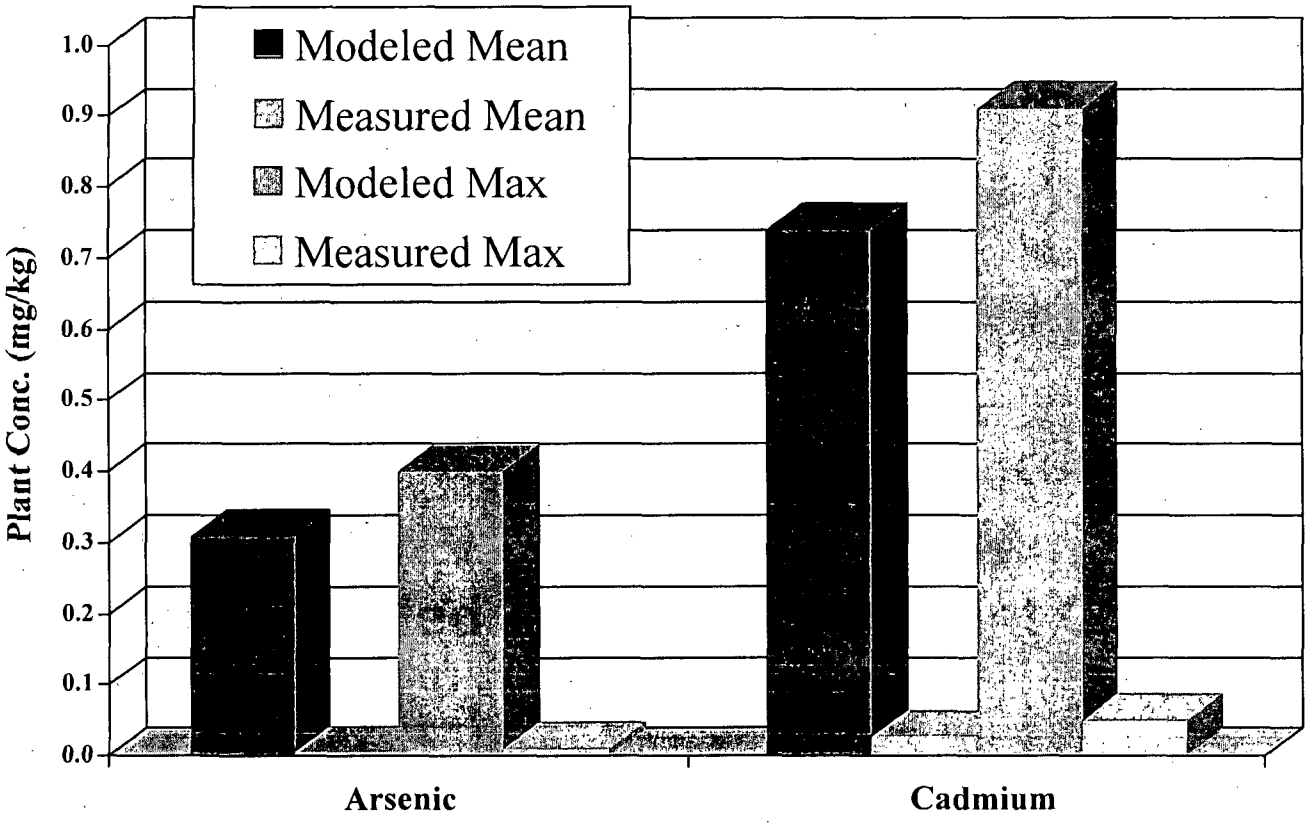
Food Pathways Highly Uncertain

- Much of risk from food pathway due to background concentrations in soil
- Metals concentrations in foods modeled from soil concentrations; *high degree of uncertainty*.
- All assumptions conservative; tend to overestimate risks
  - Soil concentration: Homegrown vegetables likely require soil amendments
  - Uptake of metals from soil to plants or grass
  - Soil ingestion rates for cow, chicken
  - Transfer of ingested metals to meat (beef, chicken) & from chicken to egg
  - Ingestion rates for homegrown vegetables, beef, chicken, eggs

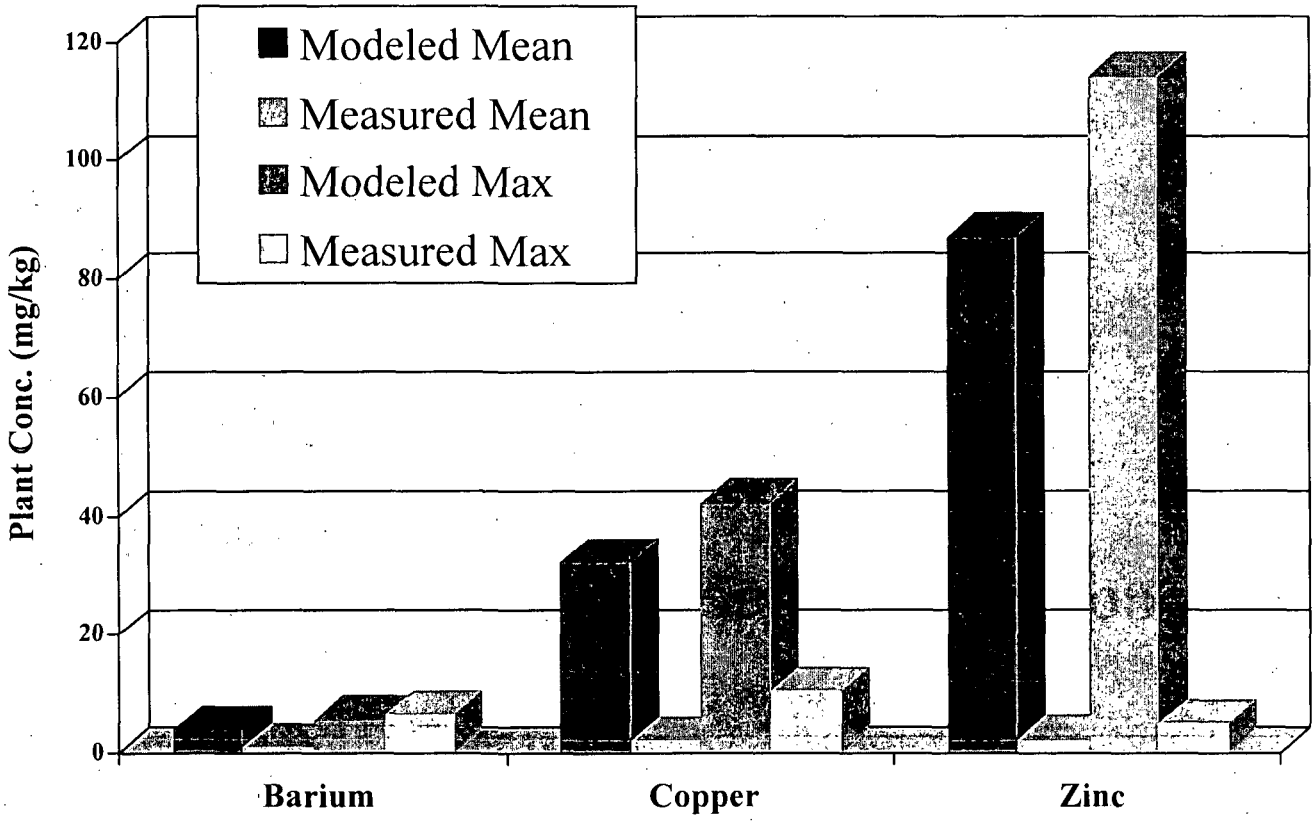
Hurley Modeled vs. Measured Plant Concentrations

- Hurley Homegrown Garden Plant Investigation (Golder Associates, August, 2001)
- Soil & 8 garden plants from 3 Hurley gardens
- 9 Reference plants from grocery store
- Tomatoes, Chilies, Chard, Onions
- **Measured** plant concentrations **<u>much lower</u>** than **modeled** concentrations
- Garden plant concentrations similar to Reference plants

Hurley Modeled vs. Measured Plant Conc.



Hurley Modeled vs. Measured Plant Conc.



Conclusions

- Cancer and Noncancer Risks below target levels for
  - Recreators – hikers or swimmers
  - Trespassers – hikers or swimmers
  - Ranchers
  - Construction workers
  - Industrial workers
- For both RME and CTE scenarios

Conclusions (continued)

- RME Cancer risks above $1x10^{-4}$
  - Residents in all Exposure Areas
  - Residents in Reference Area
  - >90% of risk from food pathway
- RME risks ? $1x10^{-5}$, excluding food pathway
- CTE Cancer risks below $1x10^{-4}$
  - Residents in all Exposure Areas
  - Residents in Reference Area
- Most risk is from background levels in soil

Conclusions (continued)

- RME Noncancer risks above 1
  - Child & Adult Residents in all Exposure Areas
  - Child & Adult Residents in Reference Area
  - >90% of risk from food pathway
- CTE Noncancer risks above 1
  - Child & Adult Residents in all Exposure Areas
  - Child & Adult Residents in Reference Area
  - 80-90% of risk from food pathway
- Excluding food pathway:
  - Adult: RME & CTE noncancer risks below 1
  - Child: CTE noncancer risks below 1

Question and Answer